

MULTIPLE MODALITY INTERFACE FOR IMAGING SYSTEMS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. patent application Serial No. 09/200,056 which was file on November 25, 1998 and which has the same title as this application.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not applicable.

BACKGROUND OF THE INVENTION

[0003] The field of the invention is medical imaging methods and systems. More particularly, the invention relates to a standard system which can be used to interface with any of several different imaging system types.

[0004] Traditionally medical facilities have concentrated their efforts on providing the best possible medical services to patients. One area in which the quality of medical services has progressed extremely quickly is in the medical imaging disciplines or modalities which include radiography, fluoroscopy, angiography, magnetic resonance (MR) imaging, ultrasound, nuclear medicine (NM) and computer tomography (CT).

[0005] While each of the separate imaging modalities can be used to generate medical images, the medical imaging industry has recognized that each modality is particularly suited for certain imaging techniques and that some modalities are better suited than others for observing specific anatomical phenomenon. For this reason, many medical facilities have acquired a plurality of imaging systems, each of which facilitates a different one of the imaging modalities. This is particularly true in large medical facilities which may have several imaging systems for performing each of the imaging modalities (i.e. several MR systems, several CT systems, etc.). Having several imaging systems each capable of facilitating a different one of the imaging modalities enables a physician to select the best imaging modality for a particular imaging task and therefore increases the usefulness of a resulting image for achieving the particular task. In fact, many medical facilities compete for

patients based on the abilities of their medical imaging departments. This imaging department competition places pressure on each medical facility to maintain state of the art imaging departments.

[0006] While imaging system quality has increased appreciably, the costs associated with maintaining a state of the art imaging department have Also increased appreciably. Unfortunately, despite increased costs associated with providing a state of the art imaging department, recently there has been mounting pressure on many medical facilities to reduce medical costs. For this reasons imaging departments are always looking for ways to decrease department costs while maintaining the highest possible service quality.

[0007] In addition to imaging hardware and software costs which are substantial, another expensive component to any successful medical imaging department is imaging personnel which includes radiologists and technologists. A radiologist is a trained physician who specializes in radiology disciplines and typically in other imaging modalities. Technologists are supervised by the radiologists and perform most of the setup, imaging, filming and archiving of images.

[0008] Basic training for a technologist in the imaging disciplines typically includes two years of on the job apprenticeship which focuses on the human anatomy and physiology, imaging equipment theory and operation and imaging procedures. In addition to basic training, many technologists obtain additional training in imaging specialties such as ultrasound, NM and radiation therapy. Training in each specialty typically takes about an additional year per specialty. In addition, some technologists obtain further training in sub-specialties such as computer tomography CT, MR and angiography, each of which requires further on the job training. After a successfully completed apprenticeship a technologist performs procedures under the direction of a radiologist.

[0009] Because of the differences in the imaging modalities, many medical facilities are staffed with a plurality of technologists, at least one technologist for each imaging modality practiced at the facility. Thus, in some cases a facility may include at lease seven technologists, at least one technologist for each possible modality. While necessary to have a trained technologist in each imaging modality practiced at a facility, such staffing requirements are extremely expensive.

[0010] One solution to the excessive technologist staffing problem has been to train technologists in more than a single imaging modality. For example, one technologist may be trained in both NM and CT while another may be trained in fluoroscopy and radiography.

[0011] Another solution to the excessive technologist staffing problem has been for medical facilities to share technologists. Thus, for example, a CT technologist may divide her time between three separate medical facilities, every third day spent at a different one of the three facilities.

[0012] While both of these solutions reduce costs associated with technologist staffing, each of the solutions is hampered by the current state of imaging systems and the way in which technologists are forced to interact with such systems and system information. An exemplary MR imaging session is instructive in understanding the difficulties associated with training a technologist in more than a single imaging modality.

[0013] A typical MR imaging session comprises several different steps including scheduling, analyzing patient information, patient preparation and handling, acquiring image data, displaying images, advanced processing of image data, filming display images, archiving display images, logging completed acquisitions and interpretation and reporting. Each of the different steps often requires a technologist to interact with one or several different department tools. For example, during scheduling a technologist typically uses a scheduling clipboard (i.e. paper on a clipboard) or the like to schedule imaging sessions during the course of a day. A scheduling table appears on the board which typically identifies time, patient, the type of exam required (e.g. C-spine, brain, head, etc.), status, identification number, etc.

[0014] As an alternative to a hardcopy clipboard, some facilities now have automated scheduling tools whereby a scheduling computer is used to generate a scheduling table which is consulted by the technologist throughout the course of a day to schedule and keep track of required imaging tasks.

[0015] In addition to the scheduling table, often a hardcopy (i.e. paper) requisition form will be provided for the technologist which includes additional patient identifying information (e.g. weight, height, sex, etc.), may list allergies, identifies the type of exam (e.g. c-spine, brain, head) to be performed, identifies the requesting physician and so on. Prior to imaging a requisition form is required to ensure that inadvertent imaging is not performed on

patients. Once again, some automated facilities provide a computer for accessing requisition forms.

[0016] After examining a requisition form and confirming authorization and prior to meeting a patient, the technologist typically confirms images which have to be acquired during a subsequent session. For example, while imaging a spinal section using the MR modality, it may be conventional to obtain a series of image slices along the length of the spinal section using a T1 FSE pulse sequence and a T2 FSE pulse sequence. In addition, a particular physician may routinely require a third series of image slices using an oblique axial FSE pulse sequence. To confirm required images technologists often consult a required image guidebook which includes lists of required images and may include lists of images specially required by specific radiologists. In addition, a guidebook may Also indicate required patient position and equipment position for each required image Moreover, each facility may Also have a list of standard required images which must be consulted by the technologist.

[0017] During patient preparation and handling, the technologist greets the patient, explains the imaging procedure, helps the patient onto an imaging table and guides the patient into a first position required to collect a first of the required images.

[0018] Next, during acquisition the technologist typically uses an acquisition computer to select specific images to be generated by selecting image boundaries and image parameters. To this end the technologist often will acquire one or more localizing images which can be used to generally identify the position of anatomical structures within a patient's body. Viewing the localized image the physician selects required images to be generated and can select imaging parameters to use when generating the required images.

[0019] Typically there are many different imaging parameters which can be selected and adjusted. In an effort to make acquisition computers easy to use, many acquisition computers provide an interactive interface including parameter icons for use with a pointing device to enable a technologist to select icons and change parameters with the click of a pointing device button (e.g. a mouse) or via a keyboard. To notify a technologist of all selectable parameters and iconic parameter selecting tools, interfaces of this type display virtually all parameters and associated icons on the interface for examination selection.

[0020] In addition, to help a technologist select appropriate parameter settings the imaging guidebook may Also include tables indicating standard parameter settings for each image to be formed. These standards may be selected by the facility generally and may Also

include specific required settings for each requesting radiologist. After selecting parameters the technologist causes the imaging system to acquire the selected images, the system storing the images electronically.

[0021] Next, the technologist may reposition the patient in a position optimal for collecting data for the second required image and thereafter follows the same procedure described above to collect required image data.

[0022] After required images have been stored electronically the images are downloaded onto an archive system which typically includes a second computer in addition to the acquisition computer. By downloading digital images to a second computer the acquisition computer is freed to perform a subsequent image acquisition. Many acquisition computers enable both archiving and acquisition at the same time so that, while image data corresponding to one patient is downloaded to the second computer, image data corresponding to another patient can be collected. This simultaneous dual function ability increases the throughput rate (i.e. patients/day) for the imaging system and thus overall efficiency.

[0023] After the images are downloaded to the second computer, the technologist can use the second computer to analyze the images and perform advanced image processing. Thus, for example, where ten parallel and adjacent MR images have been collected which define a three dimensional data array, a technologist may want to generate a maximum intensity projection (MIP) using three of the ten images. To this end the technologist selects the three images to form the MIP and instructs the second computer to combine the three images to form the MIP. Other advanced processes are possible and are contemplated.

[0024] After advanced processing the technologist may select all or a subset of the original or advanced process images for generating film hardcopies for physician review. After selecting images for filming a filming machine, which is Also controlled and maintained by the technologist, is used to generate required film pictures. After filming the pictures are provided to a physician for examination and thereafter are archived in a patient's file. In addition to filming, some systems Also enable digital archiving so that digital images can be reaccessed using a computer or the like for review or for subsequent advanced processing.

[0025] After a completed imaging session the technologist typically uses a binded logbook notebook to document the completed session by indicating the date, time, patient name and number, examination type and so on.

[0026] Thus, for a specific modality a technologist has to interact with several specific tools including a schedule, requisition forms, an image guidebook, an acquisition computer, a second advanced processing computer, a filming machine, an archiving database and a logbook.

[0027] While learning to use these tools for a single modality is not terribly difficult, differences between similar tools used for different modalities complicates the process of becoming proficient in two or more modalities. Thus, for example, scheduling clipboards for one imaging system may be set up entirely differently than scheduling clipboards for another imaging system. Even where two imaging systems are both automated to include scheduling computers and even where each of the two automated systems are provided by the same vendor, each computer usually includes a different interface such that entry of scheduling information into the two computers is in a unique sequence and different information may be required for each system.

[0028] Similarly, each system may have an entirely unique type of requisition form such that locating form information is a tedious task. This is true of both paper forms and automated computerized systems.

[0029] Moreover, imaging guidebooks may be relatively complex and can become difficult to use as radiologist's particular requirements are added to the books. For example, at a large medical facility there may be more than 10 radiologists who routinely require MR imaging. While each of the radiologists typically will require some identical images when a specific exam type structure (e.g. c-spine) is performed, many of the radiologists may require additional specific images which the particular radiologist finds helpful during diagnosis. In addition, while, for each required image there might be a typical patient position which is usually used to acquire the image, each radiologist may Also have a slightly different preferred position which, in the radiologist's judgment, yields a slightly better final image. In addition, where radiologist's require specific system parameter settings the technologist Also has to consult imaging guidebook tables to determine required settings. Thus, a complete imaging guidebook would have to indicate, for each radiologist, required images for each

body structure, where applicable, specific required patient positions for each required image and required parameter settings for each image.

[0030] Clearly, using imaging guidebooks is tedious work. Unfortunately, the difficulty of using such guidebooks is exacerbated by the fact that many of the guidebooks have unique forms, some systems include two or more guidebooks and many guidebooks can be supplemented as radiologists are added to or removed from the facility staff.

[0031] Moreover, acquisition computer interfaces are often very different and therefore, knowing how to use one interface does not render another interface intuitive. For example, the acquisition computers for a MR system and a CT system often have extremely different interfaces which require a technologist to step through very different protocols. This is not surprising as the parameters which have to be selected for different modalities often are different. However, the tools provided for setting even similar parameters on two different imaging systems often have a very different appearance and different operation. Thus, for example, to increase a displayed parameter value one interface may require a user to place a cursor in a parameter box and type in a desired value. Another interface may include up and down arrow icons adjacent a parameter box with a current parameter setting displayed in the box, the setting increased by selecting the up arrow via a pointing device.

[0032] Acquisition computer differences are exacerbated by the fact that most system interfaces are extremely cluttered as virtually every possible tool for setting acquisition parameters is usually provided on the interface screen, this despite the fact that many tools are only rarely used by the technologist. While designed to help a technologist by indicating all possible tools it has been recognized that such a crowded screen actually reduces technologist efficiency as the locations of the most widely used tools are obfuscated.

[0033] Furthermore, the interfaces and operation of the advanced processing computers, filming machines and archiving computers for different processes (i.e. modalities) are Also often very different.

[0034] All of the interfacing problems described above are exacerbated where a single technologist works between facilities as facility unique interfaces, guidebooks and schedules have to be decrypted by visiting technologists prior to efficient system use.

SUMMARY OF THE INVENTION

[0035] An exemplary embodiment of the invention includes a universal interface usable with at least first and second different imaging modalities, each modality including functions or procedures which are common to each of the first and second modalities, each separate instance of the interface used with only a specific one of the first or second modalities. The interface comprises a display, a programmed data processor for providing a uniform interface image on the display despite the specific modality, the uniform interface image comprising a function navigation space including function icons corresponding to procedures which are common to both the first and second imaging modalities and a workspace adjacent the function navigation space for displaying, analyzing and manipulating images of a type consistent with the specific modality and a pointing device for moving a pointer icon about the display and for selecting displayed icons. When an icon is selected, the processor correlates the selected icon with a corresponding command and executes the command.

[0036] The universal interface facilitates fast training of technologists thereby enabling inexpensive cross-modality training and technologist substitution. To this end, it has been recognized that there are several basic system processes which are common to each of the known imaging modalities. The universal interface is structured around the basic processes to provide a feeling of comfort to a technologist proficient in any imaging modality.

[0037] It has Also been recognized that, for each basic process, there is often a typical sub-process workflow which is routinely followed. Thus, preferably, each procedure which is common to the first and second modalities includes procedure specific sub-processes and the workspace includes a workflow navigation space in which, when a function icon is selected, the processor displays a workflow icon set including a separate workflow icon corresponding to each sub-process of the process associated with the selected function icon and for the specific modality. On each modality interface each of the navigation space and workflow space are similarly positioned and similarly color coded to further render a technologist comfortable using each interface.

[0038] Moreover, the invention includes one or more data tables which are accessible by an acquisition computer for guiding a technologist through the process of determining

required images and patient positions, setting proper imaging parameters for each required image and selecting desired advanced imaging processes.

[0039] Consistent with the above, the invention includes a medical image data acquisition system interface usable with at least first and second different medical imaging data acquisition systems that include first and second data acquisition hardware configurations for acquiring data using different first and second medical image data acquisition modalities, respectively, wherein the first and second modalities may be selected from radiography, fluoroscopy, angiography, magnetic resonance imaging, ultrasound, nuclear medicine, positron emission tomography and computer tomography, each modality including functions which are common to each of the first and second modalities, each separate instance of the interface used with only a specific one of the first or second modality systems and linked to a diagnostic system for acquiring data according to the specific one of the first and second acquisition modalities, the interface comprising a display, a programmed data processor for providing a uniform interface image on the display despite the specific data acquisition modality associated with the diagnostic system linked to the interface, the uniform interface image comprising a function navigation space including function icons corresponding to data acquisition procedures which are common to both the first and second data acquisition modalities wherein, each procedure which is common to the first and second data acquisition modalities includes procedure-specific subprocesses and a workspace adjacent the function navigation space for displaying, analyzing and manipulating images of a type consistent with the specific data acquisition modality and a pointing device for moving a pointer icon about the display and for selecting displayed icons, wherein, when an icon is selected, the processor correlates the selected icon with a corresponding data acquisition command and executes the command.

[0040] The invention also includes a medical imaging method comprising the steps of providing a data acquisition system of a specific modality including at least one sensor for sensing signals of the specific modality emanating from an object being imaged wherein the modality is one of radiography, fluoroscopy, angiography, magnetic resonance imaging, ultrasound, nuclear medicine, positron emission tomography and computer tomography, providing an interface usable with at least first and second acquisition systems of first and second modalities, respectively, the interface including a display, linking the interface to one of the first and second acquisition systems, providing a uniform interface image on the

display despite the linked acquisition system modality, the uniform interface image comprising a function navigation space including function icons corresponding to data acquisition procedures which are common to each of the first and second modalities wherein, each procedure which is common to the modalities includes procedure-specific subprocesses and a workspace adjacent the function navigation space for displaying, analyzing and manipulating images, providing an icon selecting means on the display, when an icon is selected, the correlating the selected icon with a corresponding data acquisition activity and performing the activity.

[0041] Moreover, the invention also includes a medical imaging system comprising a data acquisition system of a specific modality including at least one sensor for sensing signals of the specific modality emanating from an object being imaged wherein the modality is one of radiography, fluoroscopy, angiography, magnetic resonance imaging, ultrasound, nuclear medicine, positron emission tomography and computer tomography, an interface usable with at least first and second acquisition systems of first and second modalities, respectively, the interface linked to one of the first and second acquisition systems and comprising a display and a programmed data processor linked to the linked acquisition system and providing a uniform interface image on the display despite the linked acquisition system modality.

BRIEF DESCRIPTION OF THE DRAWINGS

[0042] Fig. 1 is a block diagram of an MRI system which employs the present invention;

[0043] Fig. 2 is a schematic illustrating an exemplary data table and an exemplary position image table according to present invention;

[0044] Fig. 3 is a schematic illustrating an exemplary schedule interface screen according to the present invention;

[0045] Fig. 4 is a schematic illustrating an exemplary patient information interface screen;

[0046] Fig. 5 is a schematic illustrating an exemplary acquire interface Screen;

[0047] Fig. 6 is a schematic illustrating an exemplary image viewing display ;Screen;

[0048] Fig. 7 is a schematic illustrating an exemplary analyze interface Screen;

[0049] Fig. 8 is a schematic illustrating an exemplary utilities/protocol interface screen;

[0050] Fig. 9 is similar to Fig. 8, albeit illustrating a second level of the protocol interface screen; and

[0051] Fig. 10 is similar to Fig. 9 albeit illustrating yet another level of the protocol interface screen.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0052] HARDWARE:

While the present invention is meant to be used with any imaging system despite the modality facilitated by the system, in order to simplify this explanation the invention will be described in the context of an exemplary MR system. To this end, referring first to Fig. 1, there is shown the major components of a preferred MR system which incorporates the present invention. The operation of the system is controlled from a universal interface 100 which includes an interface processor 101 that scans a keyboard 102 and receives inputs from a human operator through a display screen 104. Screen 104 may be either a plasma/touch screen or a more conventional display on which a pointer cursor is provided which can be moved via mouse 103. For the purposes of the present invention it will be assumed that mouse 103 is used to move a pointing icon or cursor on display 104.

[0053] Interface processor 101 communicates through a communications link 116 with an applications interface module 117 in a separate computer system 107. Through the keyboard 102 and mouse 103, a technologist controls the production and display of images by a processor 106 in the computer system 107, which connects to display 104 through a video cable 105 and processor 101.

[0054] Computer system 107 includes a number of modules which communicate with each other through a backplane. In addition to application interface 117 and processor 106, these include a CPU module 108 which controls the backplane and which connects the computer system 107 through a bus 110 to a set of peripheral devices, including disk storage 111 and tape drive 112. CPU module 108 is Also linked to a film machine 90 via a bus 92. The computer system 107 Also includes a memory module 113, known in the art as a frame buffer for storing image data arrays, and a serial interface module 114 that links the computer

[0055] system 107 through a high speed serial link 115 to a system interface module 120 located in a separate system control cabinet 122.

[0056] The system control 122 includes a series of modules which are connected together by a common backplane 118. The backplane 118 is comprised of a number of bus structures, including a bus structure which is controlled by a CPU module 119. The serial interface module 120 connects this backplane 118 to the high speed serial link 115, and pulse generator module 121 connects the backplane 118 to interface 100 through a serial link 125. It is through this link 125 that the system control 122 receives commands from the technologist which indicate the scan sequence that is to be performed.

[0057] The pulse generator module 121 operates the system components to carry out the desired scan sequence. Module 121 produces data which indicates the timing, strength and shape of the RF pulses which are to be produced, and the timing of and length of the data acquisition window. Module 121 Also connects through serial link 126 to a set of gradient amplifiers 127 and conveys data thereto which indicates the timing and shape of the gradient pulses that are to be produced during the scan. The pulse generator module 121 Also receives patient data through a serial link 128 from a physiological acquisition controller 129. The physiological acquisition control 129 can receive a signal from a number of different sensors connected to the patient. For example, it may receive ECG signals from electrodes or respiratory signals from a bellows and produces pulses for the pulse generator module 121 that synchronizes the scan with the patient's cardiac cycle or respiratory cycle. And finally, the pulse generator module 121 connects through a serial link 132 to scan room interface circuit 133 which receives signals at inputs 135 from various sensors associated with the position and condition of the patient and the magnet system. It is Also through the scan room interface circuit 133 that a patient positioning system 134 receives commands which move the patient cradle and transport the patient to the desired position for the scan.

[0058] The gradient waveforms produced by the pulse generator module 121 are applied to a gradient amplifier system 127 comprised of G_x , G_y and G_z , amplifiers 136, 137 and 138, respectively. Each amplifier 136, 137 and 138 is utilized to excite a corresponding gradient coil in an assembly generally designated 139. The gradient coil assembly 139 forms part of a magnet assembly 141 which includes a polarizing magnet 140 that produces either a 0.5 or a 1.5 Tesla polarizing field that extends horizontally through a bore 142. Operation of coils 139 is well known in the art and therefore is not explained here in detail.

[0059] Located within the bore 142 is a circular cylindrical whole-body RF coil 152. This coil 152 produces a circularly polarized RF field in response to RF pulses provided by a transceiver module 150 in the system control cabinet 122. These pulses are amplified by an RF amplifier 151 and coupled to the RF coil 152 by a transmit/ receive switch 154 which forms an integral part of the RF coil assembly. Waveforms and control signals are provided by the pulse generator module 121 and utilized by the transceiver module 150 for RF carrier modulation and mode control. The resulting NMR signals radiated by the excited nuclei in the patient may be sensed by the same RF coil 152 and coupled through the transmit/receive switch 154 to a preamplifier 153. The amplified NMR signals are demodulated, filtered, and digitized in the receiver section of the transceiver 150. The transmit/receive switch 154 is controlled by a signal from the pulse generator module 121 to electrically connect the RF amplifier 151 to the coil 152 during the transmit mode and to connect the preamplifier 153 during the receive mode. The transmit/receive switch 154 Also enables a separate RF coil (for example, a head coil or surface coil) to be used in either the transmit or receive mode.

[0060] The NMR signals picked up by the RF coil 152 are digitized by the transceiver module 150 and transferred to a memory module 160 which is Also part of the system control 122. When the scan is completed and an entire array of data has been acquired in the memory modules 160, an array processor 161 operates to Fourier transform the data into an array of image data. This image data is conveyed through the serial link 115 to the computer system 107 where it is stored in memory 113. In response to commands received from interface 100, this image data may be archived on the tape drive 112 or memory 111, or it may be further processed by the image processor 106 and conveyed to interface 100 and presented on display 104.

[0061] II. INTERFACE

All of the hardware described above is conventional. The present invention resides within interface 100 and system 107 and is manifest in two general concepts, a universal interface and modality guidance tools which determine information which should be provided to a technologist via the universal interface during an imaging session.

[0062] With respect to the universal interface, processes which are common to virtually all imaging modalities have been identified, sub-processes which are common to each process in a specific modality have been identified and parameters which are common to each sub-process in a specific modality have been identified. Based on the common

processes, sub-processes and parameters a set of interface screens have been developed which, despite use with each of the modalities, have many identical characteristics which are recognizable and foster a comfortable feeling, even for a technologist using a system for the first time.

[0063] With respect to the modality guidance tools, it has been recognized that each hospital, and perhaps each radiologist at a hospital, may require different images to be generated during a specific type of exam, may require specific patient positions during generation of data for certain images and may also require specific parameter settings for each image generated. The modality guidance tools consist of a set of tables stored in computer memory which are used to automatically determine required settings and images and for indicating suitable patient position-when a specific radiologist orders an exam of a specific type. After determining required images, positions and parameters using the guidance tools, icons are provided via the universal interface to guide the technologist through a properly orchestrated imaging protocol.

[0064] Referring now to Fig. 2, therein are shown two exemplary tables stored in memory 113 which are accessible to processor 106 via the common backplane and which are used by processor 106 to provide interface information to console processor 101 for guiding a technologist through an imaging process. The two tables include a data table 200 and a position image table 202. Exemplary data table 200 includes five separate types of information. The first type of information includes radiologist indicators which, for the purposes of this explanation are shown as the names of different radiologists in a first table column 204. While two radiologist names, Dr. Welby and Dr. Hanson are shown, it is contemplated that there may be many more radiologists listed.

[0065] A second type of information includes exam types which are shown in a second column 206. For each doctor listed in first column 204, every possible type of exam is listed in second column 206. Exemplary exam types shown in Fig. 2 include a C-spine type and a brain type.

[0066] For each exam type listed in the second column 206, a plurality of required images are listed in a third column 208. For example, for Dr. Welby's C-spine exam type, required images include a sagittal T2 FSE sequence, a sagittal T1 FSE sequence and an oblique axial FSE sequence. Although not illustrated, a similar list of required images would be provided for Dr. Welby's brain type examination and for each of the other types of

examinations Dr. Welby often requests. In addition, a similar list of required images would be provided for each exam type Dr. Hanson routinely requests and so on.

[0067] For each required image in third column 208 a position image address corresponding to an image stored in position image table 202 is provided. For example, for the saginal T2 FSE required image for Dr. Welby's C-spine exam type, the position image address in fourth column 210 is 001. Address 001 points to an image 212 in position image table 202 which is stored at address 001. Image 212 shows a patient laying flat on her back with legs extended on an imaging table. It should be noted that while image 212 and other images in position image table 202 are shown as simplified silhouette drawings, more detailed images are contemplated and in fact are preferred with the present invention. The more detailed images may include actual digital pictures of a model positioned in precisely required positions for imaging purposes. In addition, the position images may Also include text descriptions of ideal patient positions to help a technologist identify an ideal position. Moreover, while a single position image table is illustrated in Fig. 2, memory 113 (see Fig. 1) may include a separate position image table for each radiologist listed in data table 200. Furthermore, the position images in table 202 may Also indicate desired equipment positions relative to a patient (e.g. location of a CT camera relative a patient).

[0068] Referring still to Fig. 2, for each required image in third column 208, a plurality of tools and default parameter settings for a specific radiologist and specific exam type are listed in fifth column 214. Importantly the parameters listed in fifth column 214 are only the most important parameters and the most often modified parameters for a particular imaging modality. The tools listed in column 214 are the tools which are necessary for modifying the default parameter values.

[0069] It should be appreciated that while the tables shown in Fig. 2 provide data and position images for each radiologist for MR imaging, a separate yet similar table is provided for each of the other six imaging modalities in imaging system memories earmarked specifically for those other modalities. For example, a CT system would include tables similar to table 200 and 202 which identify each radiologist, exam types, required images, position image specifiers and parameters and tool specifiers.

[0070] Referring now to Fig. 3, an exemplary interface screen 216 which is provided on display 104 is illustrated. Screen 216 generally includes two spaces including a domain space 218 and a dynamic space 220. Generally, within domain space 218, three separate

domain icons including a schedule icon 220, a log book icon 224 and a utility icon 226, are provided. Each of the domain icons 222, 224 and 226 can be selected by using mouse 103 (see Fig. 1) to move a pointing cursor or icon 228 about screen 216. Each of domain icons 222, 224 and 226 is used to open an entirely different application of the inventive interface system. Generally, schedule icon 222 enables a technologist to review and modify a patient schedule corresponding to a specific imaging system. Log book 224 enables a technologist or radiologist to review a log book of completed imaging sessions and, where images are digitally archived, enables the technologist to retrieve and review the archived images. Utilities icon 226 allow the technologist to perform a number of tasks including, but not limited to, retrieving archived records and modifying the default settings which are illustrated in the tables of Fig. 2.

[0071] Initially, when a technologist logs on to interface 100, the technologist is provided with a simple screen including domain space 218, dynamic space 220 and the domain icons 222, 224 and 226 spaced in a single row within domain space 218. Spaces 218 and 220 are differently colored to easily distinguish there boundaries.

[0072] Referring still to Fig. 3, when schedule icon 222 is selected processor 106 accesses a current patient schedule which is stored in memory 113 and performs four separate functions via control processor 101 which are observable on screen 216. First, processor 106 indicates selection of the schedule icon 222 by providing a "digital tab" 230 which encompasses the schedule icon 222 within dynamic space 220 to distinguish selected icon 222 from the non-selected icons 224 and 226 which remain within domain space 218. Second, processor 106 displays the current patient schedule on a digital clipboard metaphor image 232. Metaphor image 232 resembles a conventional hardcopy clipboard which is typically used by technologists to maintain a patient schedule. The schedule on image 232 may include any of several of different types of information, the exemplary schedule of Fig. 3 including a time column 234, a patient name column 236, a patient ID column 238, an exam type column 240 and a status column 242 which indicates whether or not an imaging session has been completed, is in a waiting state or is scheduled for a subsequent time.

[0073] Third, processor 106 provides display modifying icons including an add patient icon 244 and an update patient icon 246 which can be used to modify the schedule on image 232. Although not illustrated, it is contemplated that when one of the modify icons 244 or 246 is selected, a window opens up which provides tools to enable a technologist to add,

delete or modify information corresponding to any of the information listed on image 232. Methods and software for performing these tasks are well known in the art and therefore are not explained here in detail.

[0074] Fourth, processor 106 provides a search box 248 and a find icon 250 which can be used together to locate a specific patient on patient schedule image 232. To this end, a patient's name can be provided in box 248 and thereafter icon 250 can be selected at which time processor 106 searches the table stored in memory 113 and locates the indicated patient.

[0075] In addition to the four identified processor functions which are recognizable via display 104, processor 106 Also provides a memory 113 address for each patient exam provided on image 232, the memory address invisible to the technologist but nevertheless linked to a specific exam. A specific exam and associated memory address operate like an Internet hyperlink to allow a technologist to access a radiology request form associated with the specific exam and stored at the memory address by selecting the specific exam using icon 228.

[0076] Referring to Figs. 1 and 3, using mouse 103 a technologist can select any of the icons illustrated on screen 216 by placing icon 228 on the illustrated icon and pressing a recognizable sequence of mouse buttons. While schedule image 232 is being examined, a technologist can place pointing cursor 228 on any patient name which appears on image 232 and, by selecting the patient's name, can access a digital radiology request form corresponding to the patient and the specific exam. In particular, prior to every imaging session, a technologist must review a radiology request form to make sure that the imaging session has been authorized by one of the radiologists and to identify any special instructions provided by the radiologist. In Fig. 3, it is assumed that for each exam having a "complete" status, the technologist has already reviewed a radiology request form, met with the patient, set up an exam, performed an imaging session to generate imaging data and has downloaded the imaging data to either of devices 111 or 112. However, for the exams having a "waiting" status Indicator in column 242 of image 232, the technologist has not yet accessed a radiology request form.

[0077] To access the radiology request form, as indicated above, the technologist uses cursor 228 to select the next exam having a "waiting" status in image 232. In this case, the technologist selected Mike Jones. When selected, the entire row of data in image 232

corresponding to Mike Jones is highlighted. A second selection causes processor 106 to move from a scheduling domain into an imaging session domain.

[0078] Referring now to Fig. 4, an interface screen 250 provided by processor 106 when Mike Jones is selected via image 232 is illustrated. Screen 250 includes both the domain space 218 and the dynamic space 220. However dynamic space 220 is now divided into a primary navigation space 252 which, in the exemplary illustration, includes a single column along the left-hand side of dynamic space 220 and a work space 254.

[0079] Processor 106 provides a plurality of function icons in navigation space 252. Importantly, the function icons in space 252 have been selected to mirror processor functions which are common to virtually all imaging modalities. Therefore, the navigation space icons can be provided on separate interfaces corresponding to every type of imaging system. Thus, for example, while the interface screen 250 shown in Fig. 4 is specifically for an MR system, an interface having both the domain space 218, including icons, and the navigation space 252, including navigation space icons, would be provided for a CT interface, a radiography interface, a fluoroscopy interface and so on. This feature which clearly defines specific and common functions between all imaging systems fosters a sense of comfort when a technologist moves from one imaging system type to another imaging system type or from one medical facility to another. This common interface Also helps guide the technologist through an imaging session.

[0080] Referring to Fig. 4, the navigation space icons includes a patient information icon 256, an acquire icon 258, a view/film icon 260, an analyze icon 262 and a close icon 264. It should Also be noted that all of the navigation space icons are arranged in a single column which follows a normal workflow pattern from the patient information icon 256 through the acquire icon 258, the view/film icon 260, the analyze icon 262 and the close icon 264. This feature enables a technologist to clearly see a required or desired workflow pattern.

[0081] Referring to Figs. 1, 3 and 4, when a technologist selects Mike Jones on interface 262 processor 106 accesses memory 113 and retrieves the radiology request form which is stored at the address corresponding to the exam for Mike Jones. Retrieving the radiology request form processor 106 displays the request form in workspace 254. In addition, to clearly indicate that the information in workspace 254 is associated with the patient information icon 256, processor 106 encompasses patient information icon 256 in workspace

254 by providing a digital tab 266 which includes patient information icon 265 in workspace 254.

[0082] Referring still to Fig. 4, an exemplary radiology request form 255 includes a requisition number 268, patient identification information (e.g. name, id number, age, weight, etc.) generally referenced by numeral 270 and exam request information indicating the type of exam required, relative patient history, a required protocol, the referring doctor, the responsible radiologist and so on, collectively referred to by numeral 272. In addition, processor 106 may include a space 274 where the technologist can input her name to complete the radiology request form. Although not illustrated, iconic tools for modifying the protocol or other request form information may be provided within workspace 254, the tools selectable via pointer icon 228.

[0083] After the technologist has examined the radiology request form to determine a required protocol and ensure proper authorization of the exam, the technologist selects acquire icon 258 via icon 228. Referring now to Fig. 5, when acquire icon 258 is selected, processor 106 indicates selection of acquire icon 258 by providing a digital tab 276 which encompasses acquire icon 258 within workspace 254. In addition, processor 106 divides workspace 254 into a workflow navigation space 278, an imaging window 280 and a parameter settings space 282. Workflow navigation space 278 preferably includes a single column adjacent navigation space 252. In the exemplary illustration, the imaging window is in the upper right-hand corner of workspace 254 while parameter settings space 282 encompasses the remainder of workspace 254.

[0084] Referring now to Figs. 1, 2, 4 and 5, in addition to dividing workspace 254 as described above, when acquire icon 258 is selected, processor 106 identifies the radiologist indicated on the request form 255 and the required protocol from the request form and uses those two pieces of information to access a specific set of required images and parameters in table 200 which is stored in memory 113. In the present example, processor 106 identifies Dr. Welby and his C-spine protocol as the exam type and accesses memory 113 to identify four required images including a "localizer" a "Sag T2 FSE", a "Sag T1 FSE" and a "ob ax FSE" image. For each of these required images, processor 106 provides a separate icon within space 278. The icons are identified by numeral 284, 286, 288 and 290, respectively and are collectively referred to as a workflow icon set. Each of the workflow icons includes a virtual

button and an LED illustration which, when the icon is selected, lights up. For example, localizer icon 284 includes LED illustration 292.

[0085] Importantly, just as the function icons in navigation space 252 are provided in a typical workflow form from top to bottom, workflow icons in space 278 are Also provided in a similar top to bottom workflow pattern. To this end, localizer icon 284 is first listed and therefore generally first selected to generate a "localizer" image in image window 280 which can be used to determine general patient and anatomical body position with respect to system hardware. Thereafter other icons 286, 288 and 290 are selected to generate three different types of image sets and the typical order is Sag T1 FSE, Sag T2 FSE and ob ax FSE.

[0086] Referring to Figs. 1, 2 and 5, initially, when localizer icon 284 is selected, no image is provided in window 280. However, all of the parameters and tools indicated in the fifth column 214 of table 200 which correspond to the localizer image for Dr. Welby's C-spine type exam are provided in space 282. All of the parameter values provided are the default values indicated in table 200. Each of the parameter values can be changed using iconic tools provided in space 282. For example, to change the pulse sequence of the plane through which a localizer image is taken, a technologist can select a technique tool icon 300 via icon 228. Although not illustrated, when one of the tool icons such as technique icon 300 is selected, it is contemplated that a window opens up providing tools to modify all of the parameters corresponding to technique (e.g. pulse sequence and plane). Similarly, a range tool icon 302 is provided, a scan tool icon 304 and a processor tool icon 306 each of which, when selected, opens a window for modifying parameters associated therewith.

[0087] Referring still to Figs. 2 and 5, the parameter values and tools in space 282 are referred to generally as a commonly modified parameter set and associated tools. In addition to displaying all of the parameters values and tools indicated in column 214 of table 200 in space 282, processor 106 Also provides a tool box icon 308 which, when selected, opens another window which includes a relatively large number of additional parameter values and tools which are only seldomly used during localizer imaging. These additional values and tools are referred to generally as a seldomly modified parameter set and associated tools. The idea here is that by providing seldomly used tools in a hidden yet easily accessible format (i.e. "behind" a tool box icon), the screen display is less cluttered and routinely used tools and selected parameters can easily be located. Preferably processor 106 Also provides an image position window 310 in space 282 which indicates a patient position via an image from the

position image table 202 which is indicated in fourth column 210 of data table 200. In the present example the displayed image in window 310 is the first image in position image table 202 as indicated in column 210.

[0088] Thus, after selecting localizer icon 284 the technologist can observe the image in window 310 to determine the correct position for the patient and can review all of the default settings for the exam type for the particular radiologist. If the radiologist requested specific parameter values which are different than the default settings, the technologist can use the iconic tools to modify the parameter values. Once the patient is properly positioned and all of the parameter values are properly set, the technologist selects an accept icon 312 indicating to the imaging system that a localizer image should be generated.

[0089] Thereafter, a localizer image is generated via the system of Fig. 1 and the image appears in window 280 which is observed by the technologist. If desired, the technologist can generate several different localizer images until patient and anatomical body position is well known.

[0090] Next, referring to Figs. 2 and 5, after a suitable localizer image has been generated, the technologist selects icon 286 to set up the Sag T2 FSE imaging session and then generates the required image set. Although not illustrated, when icon 286 is selected, processor 106 provides space 282 in a manner similar to that illustrated in Fig. 5, albeit providing parameter values, tools and a position image window corresponding to the data stored in table 200 which is associated with the Sag T2 FSE required image set. Again, with the parameter values, tools and position image provided in space 282, the technologist positions the patient accordingly and may modify some of the default parameters prior to selecting the accept icon 312 to generate a series of images corresponding to the desired protocol.

[0091] A similar process is performed to generate a series of images for each of the Sag T1 FSE and Ob Ax FSE icons 288, 290, respectively. All of the generated images are stored in memory 113.

[0092] Referring now to Fig. 6, after all of the data or all of the required images has been collected and stored in memory 113, the technologist selects the view/film icon 260 to review the collected images. When icon 260 is selected, processor 106 indicates selection of icon 260 by providing a digital tab 314 which encompasses icon 260 in workspace 254. In addition, processor 106 maintains workflow icons 284, 286, 288 and 290 in space 278.

Processor 106 Also provides film and display tool icons 316 and 318, respectively, behind which various tools are hidden in window form, the tools described in more detail below.

[0093] The technologist can select any of the workflow icons 284, 286, 288 or 290 to display corresponding images in space 254. As illustrated, when icon 286 is selected, an image in a first box 320 includes an axial slice through a patient and provides phantom lines collectively referred to by numeral 322, each of the lines 322 corresponding to a separate one of the following images displayed in space 254. Processor 106 divides space 254 equally into a plurality of separate spaces and provides a separate image in each one of the spaces, each image corresponding to a separate one of lines 322.

[0094] After reviewing images, a technologist can use interface 100 to perform advanced processing techniques on the images thereby generating even more informative images for a radiologist to use. To this end, referring to Fig. 7, a technologist selects analyze icon 262. Referring Also to Fig. 1, when icon 262 is selected, processor 106 indicates selection of icon 262 by providing a digital tab 324 which extends from workspace 254 and encompasses icon 262. In the interest of simplifying this explanation, while each separate radiologist at a facility may have a specific set of advanced imaging processes that the radiologist routinely like to have performed, it will be assumed that in this case the protocol for advanced image processing for each exam type is specified by the facility and is not radiologist dependent. Thus, for a C-spine exam type, the advanced imaging protocol is identical for every radiologist at the facility. While this assumption is made in the interest of simplifying this explanation it should be recognized that a table similar to the table illustrated in Fig. 2 could be provided in memory 113 (see Fig. 1) which would be accessed by processor 106 each time the analyze icon 262 is selected. In this case, the processor 106 would identify radiologist and exam type and access an advanced imaging table to determine a required and radiologist/exam type specific advanced imaging protocol. Thereafter, the processor 106 would provide a workflow icon for each step in the advanced imaging protocol in a workflow navigation space.

[0095] In the present example it will be assumed that for a C-spine examination at Dr. Welby's medical facility the standard protocol for all radiologists includes five steps which include, in the order of normal workflow, building a three-dimensional data model, isolating a right artery, rotating and filming the right artery, isolating a left artery and rotating and filming the left artery. To this end, processor 106 provides five workflow icons in workflow

navigation space 278, the icons including a build model icon 326, an isolate right icon 328, a cine/film right icon 330, an isolate left icon 332 and a cine/film left icon 334.

[0096] Referring still to Fig. 7, when the build model icon 326 is selected, processor 106 provides three tool icons 336, 338 and 340 in work space 254. Referring Also to Fig. 6, icon 336 corresponds to all of the images in the image set associated with the Sag T2 FSE protocol. Similarly, icons 338 and 340 correspond to all of the images associated with the Sag T1 FSE protocol and the Ob Ax FSE protocol, respectively. The technologist selects one of icons 336, 338 or 340 to identify images which will be used to build the three-dimensional model and thereafter selects a build icon 342 instructing 106 to use the selected image set to build a three-dimensional model.

[0097] After the three-dimensional model is generated and stored in memory 113 the technologist steps through each of the isolate right icon 328, cine/film right icon 330, isolate left icon 332 and cine/film left icon 334 to select the specific portions of the three-dimensional model for imaging and to generate images of the selected portions. Isolating, rotating and filming are processes which are well known in the art and tools therefore are Also well known in the art and therefore those processes and tools are not explained here in detail. It should be sufficient to state that all of the tools and an image display window for performing each of those processes would preferably be provided within space 254.

[0098] Referring once again to Fig. 6, after performing advanced image processing on the images the technologist selects the view/film icon 260 once again to display the original images or the advanced processed images within space 254. Where advanced processed images have been generated, another workflow icon (not illustrated) would be provided below icon 290 which could be selected by the technologist to view the advanced process images.

[0099] Having selected the view/film icon 260, processor 106 again enables the technologist to select any of the workflow icons 284, 286, 288 or 290 to view corresponding images. In Fig. 6 icon 286 has been selected and therefore corresponding images are illustrated. With the images illustrated, the technologist can select display tools icon 318 which opens a window (not illustrated) including a plurality of other tools that allow a technologist to examine displayed images. For example, one of the tools may be a measuring tool which allows a technologist to select two points on an image and measure the distance

therebetween. Tools of this nature are well known in the art and therefore are not described here in detail.

[0100] In addition, with images displayed, the technologist may select the film tools icon 316 which opens a film tools window 350 as illustrated. Window 350 includes filming tools including a print sheet icon 352, a print series icon 354 an erase image icon 356 and a more icon 358. When print sheet icon 352 is selected, processor 106 provides data corresponding to every image in space 252 to film machine 90 and causes film machine 90 to generate either one or a plurality of hardcopy film images of the displayed imaged. When print series icon 354 is selected, processor 106 downloads data corresponding to all images corresponding to all of the workflow icons in space 278 to film machine 90 thereby causing machine 90 to generate hardcopy film images of each corresponding image. To use icon 356, first a technologist would select one or a plurality of images displayed within space 254 and thereafter select icon 356 to erase the selected image from space 254. It is so contemplated that other filming tools could be accessed by selecting the more icon 358.

[0101] Referring again to Fig. 3, after filming is complete the imaging process is essentially completed for the patient and the process would begin again with the next patient on schedule image 232.

[0102] Referring again to Figs. 1 and 3, when a technologist selects logbook icon 224, although not illustrated, processor 106 indicates selection of icon 224 by providing a digital tab which extends from space 220 and encompasses icon 224. In addition, processor 106 generates a logbook metaphor image (not illustrated) which is similar to the patient's schedule metaphor image 232, the logbook metaphor image provided in dynamic space 220. To distinguish the logbook metaphor image from the schedule image 232, preferably the logbook image has a slightly different appearance. For example, the logbook metaphor image may include a spiral binder appearance along the lefthand edge of the image. Information provided on the logbook image is similar to the information provided on patient schedule image 232 except that the logbook information includes information corresponding to completed imaging sessions. To this end, exemplary logbook image information may include a date, a patient's name, the patient's ID number, an exam type (e.g. brain, head, C-spine, etc.) and a column for indicating whether or not exam images have been archived.

[0103] Referring now to Fig. 8, when a technologist selects utilities icon 226, processor 106 indicates selection by providing a digital tab 348 which extends from space

254 into domain space 218 and encompasses utilities icon 226. Utilities applications associated with icon 226 may include a number of different functions, two exemplary functions including an archive function and a protocols function which are used to store or retrieve images and to modify data and image tables (see Fig. 2), respectively. To this end, when utilities icon 226 is selected, processor 106 again separates dynamic space 220 into a navigation space 252 and a work space 254. Processor 106 provides both an archive icon 350 and a protocols icon 352 in space 252. Each of icons 350 and 352 selectable using icon 228. When archive icon 350 is selected, processor 106 provides iconic tools within workspace 254 which enable a technologist to retrieve and view archived images corresponding to previously performed imaging sessions. Tools for this purpose are known generally in the art and therefore are not described here in detail.

[0104] It is contemplated that a medical facility would likely have a set of internal policies concerning which personnel are authorized to modify default exam protocols and parameter values in data tables like table 200 illustrated in Fig. 2 for semi-permanent storage in memory 113. For example, one broad rule might be that only a radiologist is authorized to modify her default protocols and parameter values. To enforce such a rule a password security feature may be provided when protocols icon 352 is selected, processor 106 only allowing protocol modification by an authorized radiologist. While a secure system is preferred, it will be assumed that a technologist can modify default protocols and parameter values in table 200 to simplify this explanation.

[0105] When a technologist selects icon 352, processor 106 provides a digital tab 354 which extends from workspace 254 into space 252 and encompasses icon 352. In addition, processor 106 provides a protocol table 356 which corresponds to data table 200 in Fig. 2. The exemplary protocol table 356 includes two columns, first column 358 listing facility radiologists identified in table 200 and a second column 360 listing exam types (e.g. C-spine, brain, etc.) routinely requested by a corresponding radiologist. To modify the default settings within table 200, the technologist uses icon 228 to select a particular radiologist and exam type. For example, a technologist may wish to modify the default settings for Dr. Welby's C-spine exam type. To this end, the technologist selects Dr. Welby's C-spine from table 356.

[0106] Referring now to Fig. 9, when Dr. Welby's C-spine exam is selected, processor 106 provides a modify images icon 362, a modify preferences icon 364 and an accept icon 366 in workflow navigation space 278. In addition, processor 106 provides two tables, a first table

368 indicating additional image types which may be required and a second table 370 indicating already selected required image types for Dr. Welby's C-spine exam. Add and delete icons 372 and 374 are Also provided. By selecting an image type in table 368 and then selecting the add icon 372, the tools for modifying the parameter values. Once the parameter values have been set, the technologist again accepts the values by selecting an icon similar to accept icon 366 which returns the technologist back to the screen illustrated in Fig. 9.

[0107] Referring still to Figs. 2 and 9, to accept all of the changes made to table 200, the technologist selects accept icon 366 once again at which point processor 106 provides the screen illustrated in Fig. 8. Other modifications to protocols can be made in a similar fashion.

[0108] It should be appreciated that the above-described interface can be used to simplify technologist training thereby enabling less expensive technologist cross-training between imaging system modalities and enabling interfacility technologist substitution with relatively little difficulty. The guidance tools which consist primarily of guidance tables similar to those illustrated in Fig. 2 and an easily understood workflow which is presented in function and workflow icons through the inventive universal interface enable easy cross-training and interfacility substitutions.

[0109] To apprise the public of the scope of this invention, we make the following claims: